INTRAFLOW WIDTH VARIATIONS IN MARTIAN AND TERRESTRIAL LAVA FLOWS.

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Introduction. Flow morphology is used to interpret emplacement processes for lava flows on Earth and Mars. Accurate measurements of flow geometry are essential, particularly for planetary flows where neither compositional sampling nor direct observations of active flows may be possible. Width behavior may indicate a flow's response to topography, its emplacement regime, and its physical properties. Variations in width with downflow distance from the vent may therefore provide critical clues to flow emplacement processes. Flow width is also one of the few characteristics that can be readily measured from planetary mission data with accuracy. Previous modeling studies have commonly assumed relatively constant flow widths [1] and/or cross-sectional areas [2], use a single "average" value for width based upon a limited number of measurements [3-5], or do not consider width at all. Recent analyses of individual flows at two terrestrial and four Martian sites show that widths within an individual flow vary by up to an order of magnitude [6-7]. Width is generally thought to be correlated to topography [8]; however, recent studies [9-10] show that this relationship is neither straightforward nor easily quantifiable.

Classification of Lava Flow Width Behavior. A flow's width behavior may be classified on the basis of downflow trends, width trend linearity and type and rate of change, using the method of Peitersen and Crown [6-7]. For a given flow, widths are plotted as a function of downflow distance, and a linear regression line is fit to the resulting curve. This allows each flow to be classified mathematically on the basis of two characteristics: the slope (m) of the regression line and the regression coefficient (R). If $m \geq 0.1$, the flow is said to be widening in a significant manner. If $m \leq -0.1$, the flow is considered to be narrowing significantly in the downflow direction. Flows with regression line slopes that fall within these values are considered to exhibit constant width behavior. The value of R determines the relative linearity of the trend.

Analysis of Puu Oo and Alba Patera Lava Flows. Our previous efforts have focused on the behavior of individual flow lobes and flow populations at different sites. In an effort to better constrain the relationship between topography and flow width behavior, recent studies have concentrated on the relationship of width to underlying slope for different regions of individual lava flows from Episodes 1-20 of the Puu Oo eruption of Kilauea Volcano [11]. Since the distribution of width behavioral classes (predominantly constant, some narrowing, little widening) is similar for Puu Oo and Alba Patera, these are assumed to be good analogs.

Subdivision of flows. Fifty-four flows at Puu Oo (overall average slope 4.2º) and fifteen previously mapped [12] flows at Alba Patera (0.48º flank slopes [13]) were subdivided into sections. Puu Oo flows were divided into first 2 km, middle zone, and last km sections, while significantly longer Alba Patera flows were divided into proximal 1/4, medial 1/2, and distal 1/4 zones. The width behavior of each section was classified using the method discussed above. Significant differences can be observed between the overall width behavior of the Puu Oo aa flows and the width behavior of the same flows at their distal and proximal ends (Figure 1). The middle zone generally seems to characterize the entire flow; constant width behavior in this region may imply steady-state eruption conditions and/or channelization by levees. In contrast to overall flow width behavior, narrowing is more common for the final kilometer of each Puu Oo flow. Possible reasons for this distal narrowing include: 1) an increase in slope (only the ends of Puu Oo flows flow down the steep pali--average slope ~5.9º); 2) changes in rheology (due to cooling, crystallization, crust development, and loss of volatiles); 3) a drop off in supply as the eruption ends; and 4) topographic channelization. Width behavior within the first 2 km, which in general corresponds to the pahoehoe/aa transition [11] and is characterized by gentle slopes (2.3º), is far more erratic; narrowing behavior predominates, but widening also becomes more common.

These observations are supported by additional studies of 10 flows from Puu Oo Episodes 1-5, which show an increase in narrowing trends over the first 1/4 of the flow relative to whole flow trends, no significant changes for the middle 1/2, and a significant increase in narrowing over the last 1/4 of the flows. Alba Patera flows show an increased tendency to widen over the last 1/4 of their length and narrow over their first 1/4; the middle 1/2 of flows appears similar to the width behavior of the entire flow (typically constant) but with more variation. In general, regression coefficients for subdivided flow trends are greater than those for whole flows; this leads strong credence to the hypothesis that different processes may dominate width behavior in different regions of the flow.

Local correlations. The relationship between flow width and slope has been further characterized by an analysis of individual width and slope "peaks" (local maxima) and "troughs" (local minima). For ten flows from Puu Oo Episodes 1-5, the following correlations are evident: 1) width peaks align with slope troughs, and 2) width troughs align with slope peaks. These show an apparent inverse correlation between width and underlying slope, and imply a strong level of topographic control on flow emplacement (Figure 2a). However, width features cannot always be clearly correlated to slope features (Figure 2b). Major changes in width are also evident where the underlying slope is relatively constant, suggesting that some factor besides downflow topography is involved; such width changes may not be slope related, or they may document a response to slope changes in another locale (e.g., the reduction of slope downstream could cause backpressure and levee overflow upstream, or the viscosity could cause a time delay in a flow's response to topography). Even in cases where correlations between peaks or troughs exist, the magnitudes of slope and width features can be significantly different. Relatively minor changes in slope can be correlated to major changes in width, whereas at other locations major slope changes would seem to have little or no effect on width behavior. In some cases the correlation also appears to be slightly offset, possibly the result of a delayed response. Granularity of the data and relatively high levels of noise contribute to the difficulties of identifying and correlating changes in flow width and topography.

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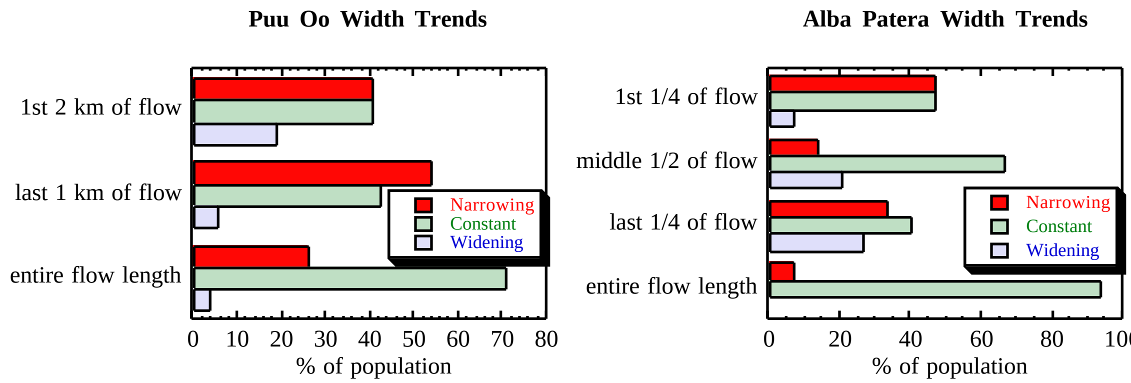

Figure 1. Puu Oo (a) and Alba Patera (b) width behavior populations show that trends vary between different parts of flows.

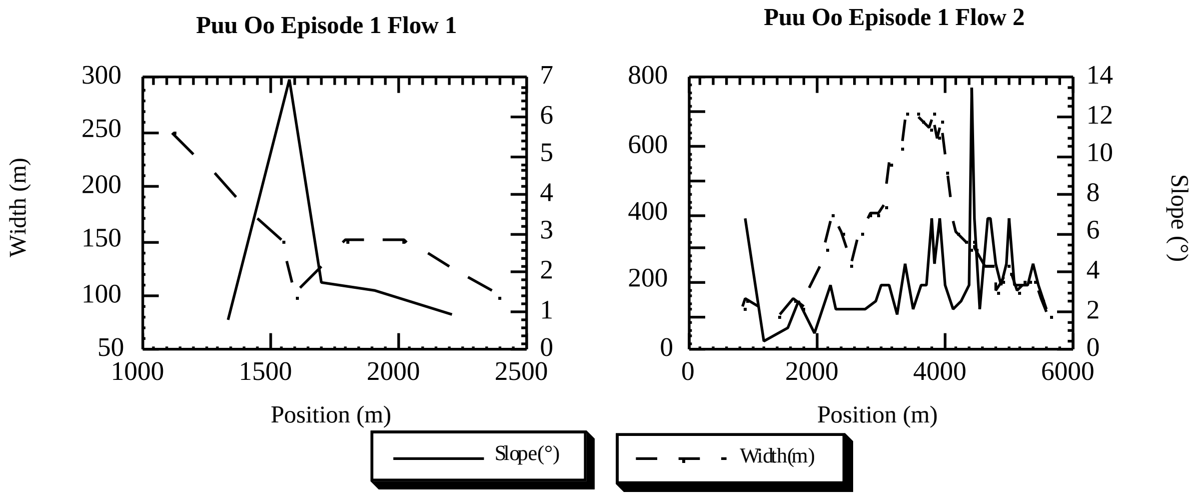

Figure 2. Examples of (a) correlation between flow width and topography, and (b) lack of correlation.